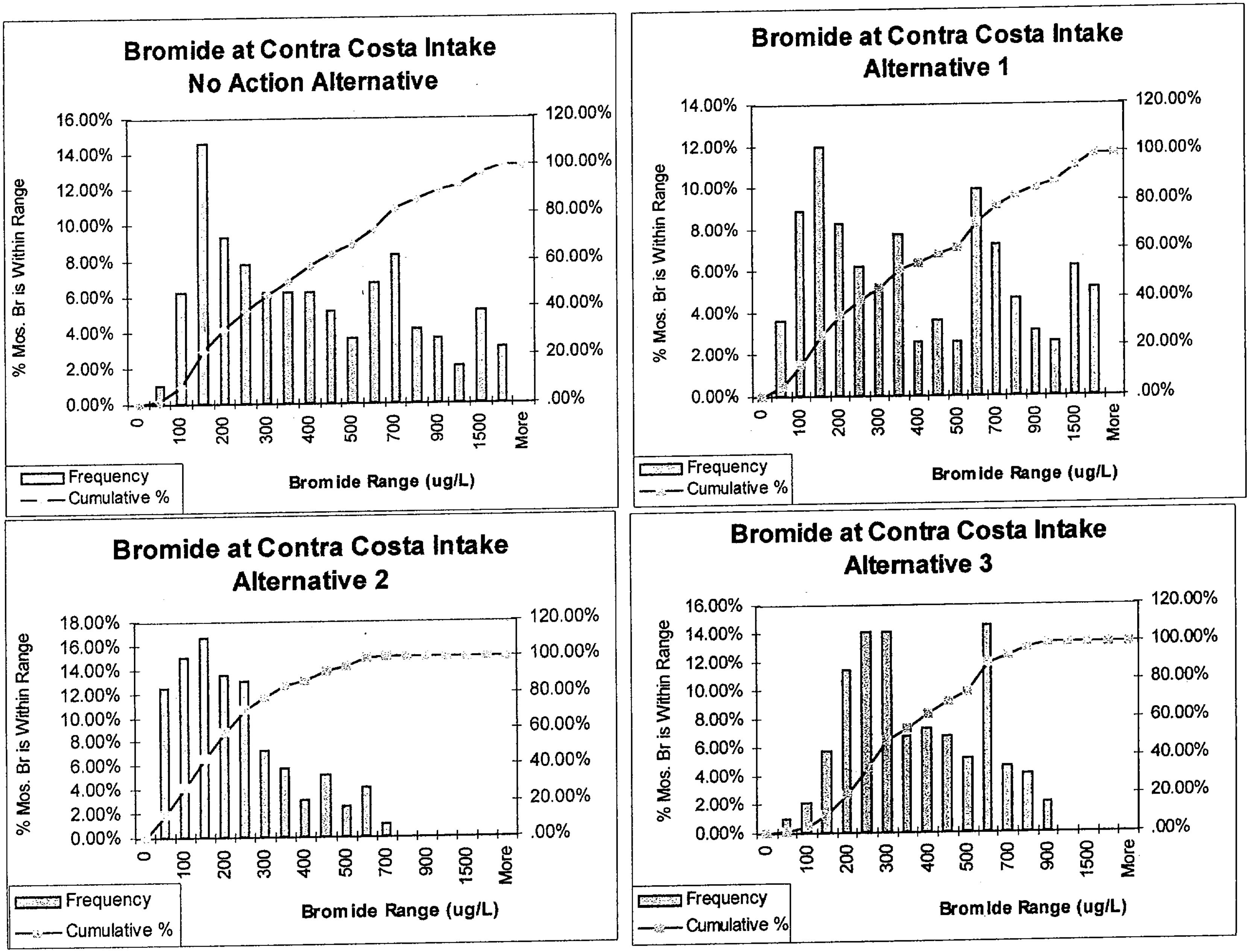

Figure 4. Bromide at Contra Costa Canal Intake

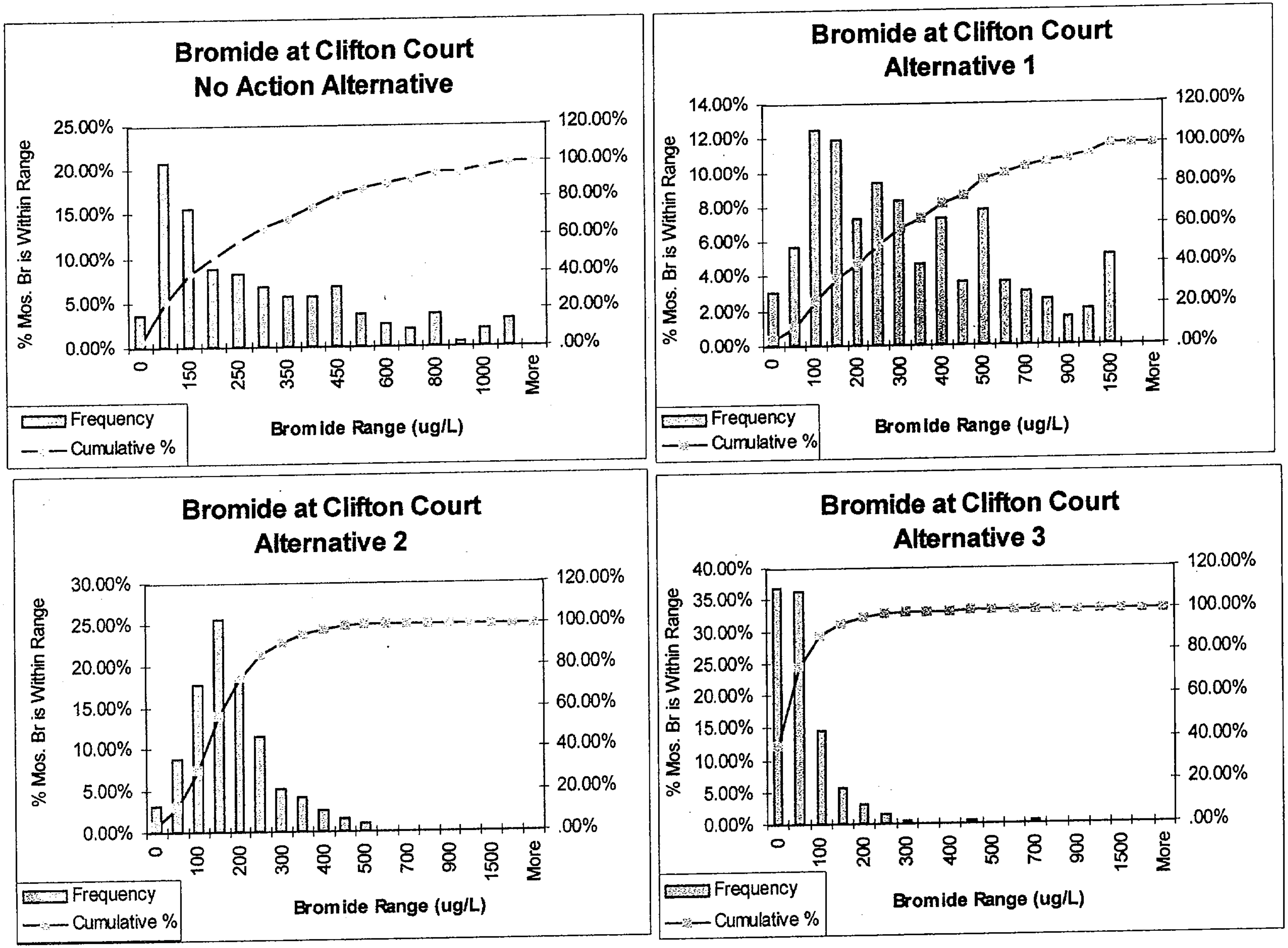

Figure 5. Bromide at Clifton Court Forebay

This section is a preliminary evaluation of the importance of non-ocean sources of bromide in the Delta system, of the potential of Water Quality Program actions to reduce bromide, and of the potential to control organic carbon in Delta drinking water supplies through water quality actions.

These analyses are intended to identify priority actions for the first stage of program implementation.

3.7.1 Bromide

In addition to saline water entering the Delta from the Bay-ocean, water flows into the Delta through the Sacramento River, the San Joaquin River, and east side streams (the Cosumnes, Mokelumne, and Calaveras Rivers) and from the Bay estuary. About 70% of the fresh-water inflow is through the Sacramento River, with the San Joaquin River making up the bulk of the remainder. The east side streams collectively contribute less than 5% of Delta fresh-water inflow. From January 1990 to March 1998, the average concentration of bromide in Sacramento River water was 18 μg/l, with a standard deviation of 40 μg/l. By contrast, San Joaquin River water averaged 310 μg/l, with a standard deviation of 150 μg/l during the same period. Therefore, although bromide concentrations in the Sacramento River are variable, this river does not appear to be an important source of bromide. It should be noted that bromide samples are collected at a sampling station on the Sacramento River about 8 miles downstream of the Sacramento Regional County Sanitation District wastewater treatment plant outfall. Therefore, the indication is that the loading of bromide from sources in the Sacramento River watershed do not play a significant role in the overall loading of bromide in the water diverted from the Delta. Similarly, the east side streams are low in dissolved minerals and are not important bromide contributors.

About 70% of the fresh-water inflow to the Delta is through the Sacramento River, with the San Joaquin River making up the bulk of the remainder.

Based on available information, it appears that the San Joaquin River is the most important source of bromide to the Delta system, exclusive of the Bay-ocean. Figure 6 depicts the south Delta. Water in the San Joaquin River normally flows into the Delta from the south, where it divides—some heading through Old River and some continuing in the river channel north to Stockton, then west toward the Bay. Pumping by the SWP, and particularly by the Tracy Pumping Plant in the south Delta, causes more San Joaquin River water to be diverted from its channel than would be diverted without pumping. Some of this water leaves the San Joaquin River to flow into Old River. Also, San Joaquin River water tends to be drawn southward to the pumps through Turner Cut and Middle River. During periods of lower San Joaquin River flow, essentially the entire river volume can be drawn into the pumps. The CVP Tracy Pumping Plant receives the highest percentage of San Joaquin River water because the plant operates continuously. The Harvey O. Banks Pumping Plant of the SWP pumps from Clifton Court,

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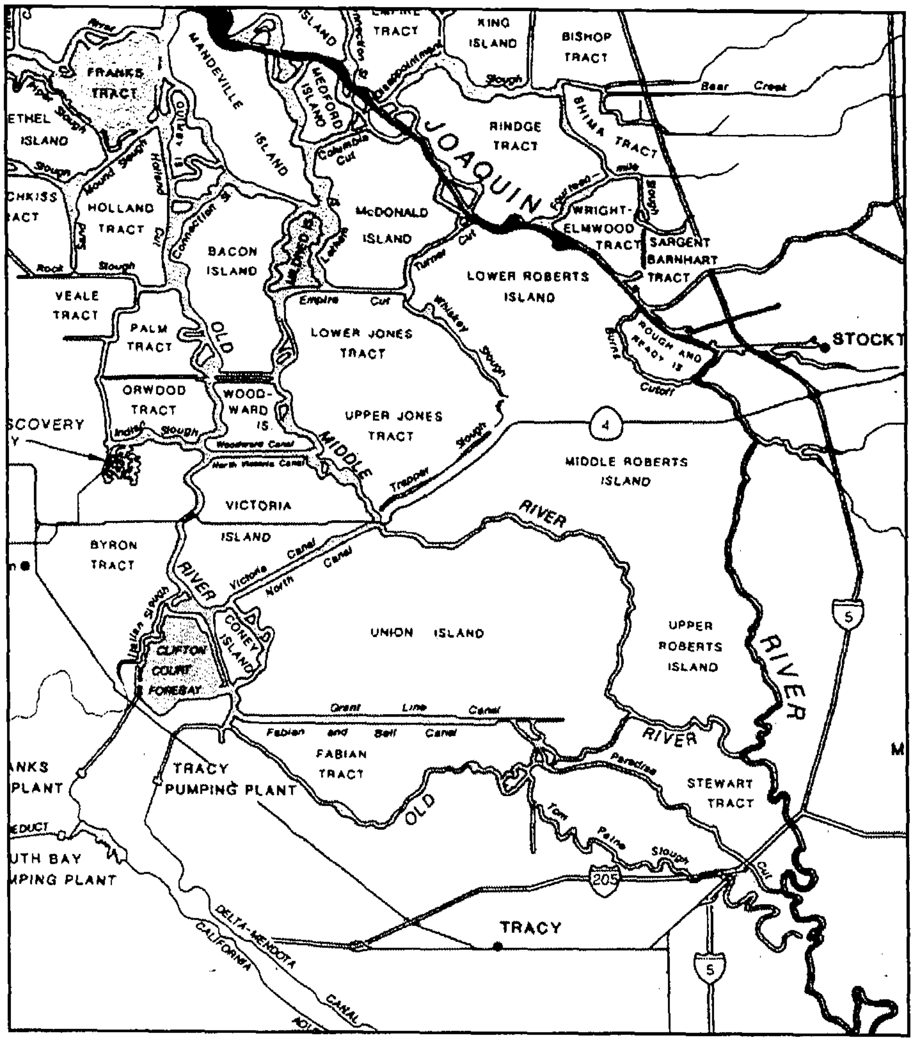


Figure 6. Vicinity Map of the South Delta

which is filled on a tidal basis. Tidal operation of Clifton Court tends to maximize the influence of the Sacramento River and thus provides somewhat better mineral quality by limiting the influence of the San Joaquin River.

Most of the water diverted through the CVP in the Delta is used for irrigation in the San Joaquin River watershed. Farmers must manage salt to avoid a buildup in the soil sufficient to cause plant toxicity. It is therefore necessary to leach salt from the soils, and this activity results in saline agricultural drainage. Drainage is discharged to the San Joaquin River, which is currently the conduit for removal of salt from the San Joaquin River watershed.

Diversion of San Joaquin River water into CVP pumps and return of agricultural drainage through the San Joaquin River creates a cycle by which salts are moved from the Delta into the San Joaquin Valley, back to the Delta, and back to the valley again. Therefore, some of the salt and bromide load leaving the valley through the San Joaquin River was introduced to the valley from the Delta as a result of sea-water intrusion. This component of the bromide load would be significantly affected by the choice of storage and conveyance alternatives.

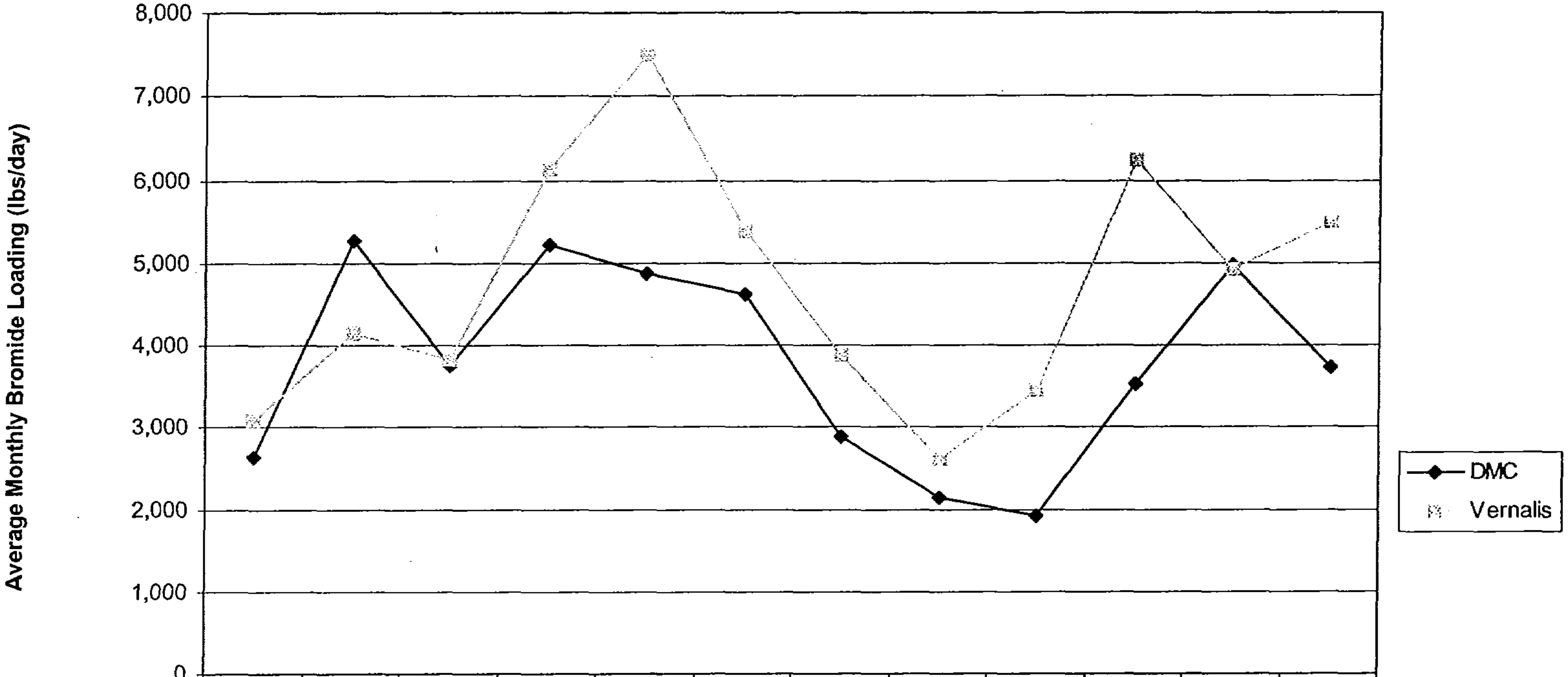
Diversion of San Joaquin River water into CVP pumps and return of agricultural drainage through the San Joaquin River creates a cycle by which salts are moved from the Delta into the San Joaquin Valley, back to the Delta, and back to the valley again.

A question of great importance to the CALFED Water Quality Program is how much of the bromide load in the San Joaquin River is not of Delta or ocean origin. A preliminary answer to this question can provide a basis for realistic expectations as to what amount of benefit can be achieved through actions along the San Joaquin River, and can help to identify priorities for water quality actions to be taken during the first stage of program implementation.

Using flow data from the USGS and bromide data from DWR's MWQI Program, daily bromide loads were computed for the DMC at the Tracy Pumping Plant and for the San Joaquin River near Vernalis (near the point where the river flows into the Delta). Daily loads were averaged by month and are depicted in Figure 7.

Overall, the bromide load entering the San Joaquin Valley through the DMC was computed to be about 80% of the loading appearing in the San Joaquin River near Vernalis. The period of record for this analysis is January 1990 to September 1996. Loading calculations were made using the average daily flows on the days samples were taken.

The ratio of bromide to chloride in sea water has been found to be constant at 0.0034. A useful way of evaluating bromide sources in the Delta is to examine the association with chloride. Based on data collected through DWR's MWQI Program, the bromide to chloride ratio in the DMC and San Joaquin River are 0.0032 and 0.0031, respectively. These data indicate strong sea-water influence.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
DMC	2,623	5,260	3,758	5,205	4,878	4,612	2,875	2,133	1,907	3,540	4,957	3,737
Vernalis	3,089	4,138	3,817	6,125	7,501	5,403	3,870	2,607	3,450	6,236	4,912	5,492

Month

Figure 7. Bromide Loadings at the Delta-Mendota Canal and the San Joaquin River at Vernalis

Taken together, the relative loads of bromide in the system and the ionic ratios clearly indicate that most of the bromide load appearing in the San Joaquin River is from sea-water intrusion.

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While it may be true that most of the bromide coming from the San Joaquin Valley is a result of sea-water intrusion, it has also been suggested that additional bromide loading in the San Joaquin River watershed may be a factor. The use of bromide in agriculture has been hypothesized to be a significant source. Methyl bromide is used in the San Joaquin Valley as a soil fumigant. Based on usage data derived from the California Department of Pesticide Regulation (DPR), an average of about 400,000 pounds of active ingredient were used on soils annually in Madera, Mariposa, Merced, San Joaquin, and Stanislaus Counties from 1992 to 1995. Some proportion of this poundage could presumably have been converted to bromide and migrated to the San Joaquin River.

Based on 135 bromide samples collected between 1990 and 1998 and subjected to quality control/quality assurance procedures by DWR, the ratio of bromide to chloride has not varied significantly from the sea-water ratio. If methyl bromide were a significant contributor of bromide to the river system, the bromide to chloride ratio should be higher, as bromide from this source would not be accompanied with additions of chloride. The lack of an evident ratio shift indicates that bromide from methlyl bromide use is not an important source of bromide loading in the system. Use of methyl bromide for soil fumigation is expected to end in 2005 by decree of the EPA. San Luis Reservoir is another hypothesized source of bromide in water supplies delivered to the South Bay and Southern California. According to this hypothesis, geological strata in the reservoir or in its watershed may be a source of bromide that is leached into the water, then transported to South Bay and Southern California municipalities.

The lack of an evident ratio shift indicates that bromide from methlyl bromide use is not an important source of bromide loading in the system.

Figure 8 depicts the vicinity of San Luis Reservoir. San Luis Reservoir is a shared facility, 60% of which belongs to the CVP and the remainder to the SWP. Water enters the reservoir from O'Neill Forebay. Water flows out of the reservoir through the Santa Clara Valley Water District (SCVWD) intake facility on the west side of the reservoir. The San Luis Pumping/Generating Plant, located between O'Neill Forebay and San Luis Reservoir, permits bidirectional flow. Therefore, the reservoir also releases to O'Neill Forebay. Water enters O'Neill Forebay from Check 12 of the California Aqueduct, located on the north side of the forebay. CVP water enters the forebay through O'Neill Pumping Plant, which connects the DMC to O'Neill Forebay and is located on the northeast side of the forebay. Water leaves O'Neill Forebay either to San Luis Reservoir or to the San Luis Canal through Check 13, located on the southeast of the forebay. Both federal and state water flows out through Check 13.

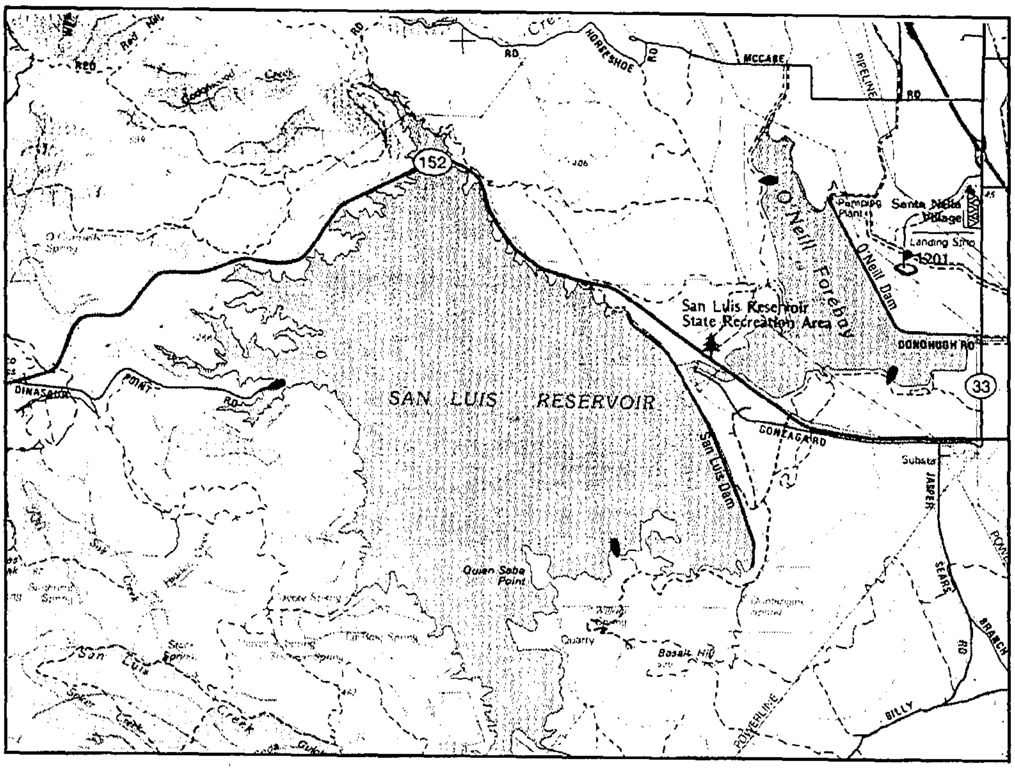


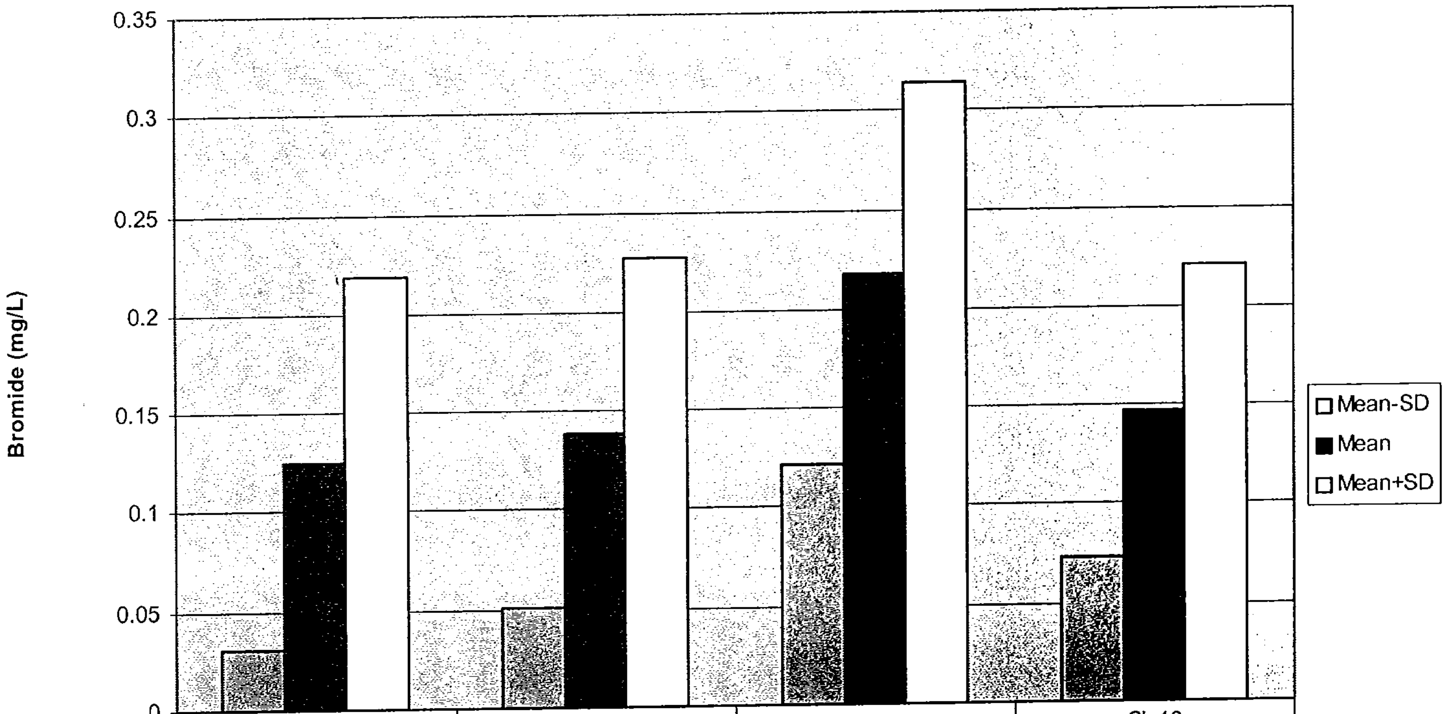
Figure 8. Vicinity Map of the San Luis Reservoir

Figure 9 depicts bromide concentrations measured at various points in the San Luis Reservoir vicinity from 1994 to January 1995. The Harvey O. Banks Pumping Plant location represents bromide in SWP water entering the forebay, DMC represents bromide entering O'Neill Forebay through the DMC, San Luis reflects bromide concentrations in San Luis Reservoir water delivered to the SCVWD, and Check 13 represents bromide in water leaving O'Neill Forebay on its way to Southern California. Water flowing through Check 13 contains a mixture of SWP, CVP, and San Luis Reservoir water. Bromide concentrations in San Luis Reservoir were measured as somewhat higher than those found in either the SWP or DMC inflows. This effect appears to be reflected in marginally higher bromide concentrations of water flowing through Check 13. These increases are not pronounced, however, and may be due to the concentrating effect of evaporation in the reservoir and to filling the reservoir with water having elevated bromide concentrations. An additional consideration is that the San Luis Reservoir data were produced by SCVWD, whereas the other data were produced by DWR. Although the data from both sources appear reasonable, further evaluation will be needed to determine whether the data from these sources are strictly comparable. Potential sources of error may include use of different analytical instruments and different sampling dates.

Empire Tract in the Delta is known to contain bromide in groundwater that is thought to be of connate (ancient sea water) origin. Drainage from Empire Tract has been measured to contain bromide ranging from 0.40 to 2.5 mg/l, as compared to nearby King Island where bromide ranged from 0.09 to 0.11 mg/l. According to data from a 1990 DWR report that were analyzed by MWD, drainage from Empire Tract accounts for less than 3% of the total drainage volume from Delta lowlands, and the contribution of bromide from this source is minimal in comparison to other sources. Figure 10 summarizes the results of this analysis.

3.7.2 Organic Carbon

Figure 11 depicts organic carbon concentrations at selected Delta locations, as measured by DWR's MWQI Program. The presence of organic carbon in waters diverted through the NBA is a particular cause of concern and is discussed specifically in Section 3.6.3 of this report. The discussion centers on developing a reasonable expectation of what might be done to control organic carbon concentrations in waters diverted from the south Delta, exclusive of the storage and conveyance options chosen for the CALFED Program. MWD estimates that the CALFED alternatives could result in the following organic carbon concentrations in water exported from the Delta through the Harvey O. Banks Pumping Plant.



	Banks	DMC	San Luis	Ck 13
Mean-SD	0.031	0.051	0.122	0.073
Mean	0.125	0.139	0.218	0.147
Mean+SD	0.219	0.227	0.314	0.221

Location

Figure 9. Bromide in the San Luis Reservoir Area